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STRATIGRAPHIC NOMENCLATURE IN THE UNITED STATES

By

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UNITED STATES GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATIONS

STRATIGRAPHIC NOMENCLATURE IN THE UNITED STATES

By John B. Reeside, Jr.

INTRODUCTION

A perfect classification of the rocks of the earth would not only provide units recognizable wherever present and a nomenclature universal in application, but it would also most effectively bring out the geologic history recorded in the faunal content, the lithologic constitution, and the structural relations of the rocks. Only a small advance toward such a perfect classification has been made, however, and it seems likely that even a near approach to it is remote—perhaps unachievable. The nearest approximation at present is in the division of the rocks into geologic systems, though even here there is considerable lack of uniformity in the usages of different geologists and organizations. For lesser units more or less local classifications are the rule, and the departure in practice from an ideal classification, both in the actual application of names and in the principles concerning their application, is very great indeed.

At first sight the systems of nomenclature in vogue in Europe seem much more simple and more nearly in agreement with one another than those in vogue in the United States and in these features more satisfactory. Part of this disparity is perhaps due to an important difference in point of view—that of emphasizing a faunal basis of division rather than a lithologic basis. Part of it is perhaps not as real as it seems, for closer inspection reveals in Europe as well as in America a considerable measure of uncertainty and confusion of usage. The geologist must as often in one continent as in the other consider for a given name the locality, the date of usage, and the individual author. Many of the difficulties met in both Europe and America are inherent in any attempt to apply a classification and a nomenclature to a natural system and are therefore not fairly chargeable against either nomenclature.

Inasmuch as the members of the International Geological Congress may not all be familiar with the basis of stratigraphic classification used in the United States, and inasmuch as it is difficult for anyone to keep in mind the details of the nomen-

clature used in a relatively unfamiliar region, it has seemed worth while to present a brief summary of stratigraphic practice in the United States and a set of correlation tables showing a European system of nomenclature and representative American systems.

BASIS OF CLASSIFICATION IN THE UNITED STATES

In the United States a very complex classification of the sedimentary rocks has grown up, and with it a complex nomenclature. For the major units, although various departures from European practice have been proposed, especially in the classification of the Paleozoic,[1] American geologists have in the main attempted to identify the divisions commonly recognized in Europe and have adopted most of the European names for them. For the lesser units they have, as a rule, made their own divisions and coined their own names. The number of names is already large and is steadily increasing; no one could possibly learn them all without effort unduly great in proportion to the advantage gained. Even a casual inspection of a reasonably complete card file of American stratigraphic names or of a set of detailed correlation charts will be sufficient to demonstrate the number of terms involved and the intricacy of their relations.

The causes of the greater complexity of the American nomenclature are several. In rather minor part it is due to certain features in usage. To some extent names have been duplicated for entirely unrelated units; for certain names several or even many differing definitions have been accepted; different names have been applied to the same chronologic unit at different places; and different names have probably been applied to the same lithologic unit at different places. In major part, however, the complexity is due to the widespread acceptance of lithologic rather than faunal units as the basis of the nomenclature, a practice, which, because of the large area of the United States, its division into provinces with different geologic history, and the necessity for applying names in disconnected areas in advance of the solution of regional stratigraphic problems, has led to the introduction of many names.

Powell,[2] in discussing many years ago the geologic maps made by the United States Geological Survey, stated very clearly a guiding principle of classification that seems to have represented

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[1] See Wilmarth, M. G., The geologic time classification of the United States Geological Survey compared with other classifications: U. S. Geol. Survey Bull. 769, 1925.

[2] Powell, J. W., Methods of geologic cartography in use by the United States Geological Survey: Internat. Geol. Congress, 3d sess. (Berlin, 1885), Compt. rend., pp. 229–232, 1888.

the majority opinion then and even to-day sets forth fairly well the facts, if not the basis, of common practice in the United States. Powell wrote:

The maps are designed not so much for the specialists as for the people, who justly look to the official geologist for a classification, nomenclature, and system of convention so simple and expressive as to render his work immediately available alike to the theoretic physicist or astronomer, the practical engineer or miner, and the skilled agriculturist or artisan. * * * Accordingly, the classification involved in a cartographic system designed for general use should be objective rather than theoretic; it should be based upon rock masses in their observed and readily observable relations rather than upon time intervals contemplated in historic geology, or even upon the organic remains contemplated in biotic geology; it should be petrographic rather than chronologic or paleontologic. * * * But while the minor geologic divisions must therefore have a natural basis, those of greater magnitude may be somewhat differently defined. The structural geologic unit is the "formation." It is defined primarily by petrography and secondarily by paleontology; and, in thoroughly studied regions, is generally found to constitute a genetic unit.

That there are certain disadvantages in the extensive use of lithologic units is obvious. It leads to the multiplication of local names, for example. Where changes in lithology are numerous a detailed "lithologic" nomenclature is apt to be so intricate as to approach the impracticable. There then arises a tendency to use rather thick, indefinitely defined units and often a tendency to attempt to extend the application of these units over large areas because of this same indefiniteness. One of the results is that certain names come to have little meaning unless specific localities are stated.

The use of lithologic units, as noted in the quotation from Powell, is based primarily on practical considerations. To most American geologists the principal purpose of a division of the rocks is to afford units that can most conveniently and most rapidly be recognized in the field and recorded on a map. Very often the geologist's interest is centered in the mineral resources or structural geology of a local area, where the relations of the rocks with those of remote, better-known areas are not of urgent importance. Usually he has only moderate acquaintance with paleontology and finds difficulty in using faunal criteria, even though fossils may be available. In some areas fossils are either very rare or lacking through considerable thicknesses of strata or belong to groups not well enough known to be useful. In many areas only the general features of the stratigraphy and paleontology are known, and sure correlation with units of other areas is not possible. Under these conditions local units based on lithology are by far the most serviceable.

Some of the lithologic units are, to be sure, also essentially faunal units, but this is mostly either the result of an accident in the original selection of stratigraphic boundaries or of a minor

shifting of boundaries as information is acquired in subsequent work. A few purely faunal units have been separated and treated just as if they were lithologic units, though difficulties have been met when in later work this original faunal basis of division has been overlooked by geologists more familiar with a lithologic basis. For other units a classification into faunal zones has been superimposed on a fundamentally lithologic classification and an attempt made to consider both in the stratigraphy. It nevertheless remains true as a general statement that the smaller units of American stratigraphy are convenient map units based on lithologic features.

In spite of the difficulties and of the weaknesses of the American system of nomenclature, there appears at present to be no feasible substitute. It may, in fact, have, besides the practical basis, at least one important theoretical justification. Lithologic units, by and large, are likely to approximate environmental units, and changes of environment in space and time are a most significant aspect of geologic history. The emphasis on lithologic differences inherent in this system of nomenclature may hence in part compensate its obvious disadvantage of complexity. Perhaps in time it will be possible to replace this lithologic system by a simpler and more nearly universal system of chronologic units based on faunal features, but at the present day, even where studies have advanced farthest toward a faunal-chronologic classification, the lithologic groupings of the earlier work are still useful.

TIME TERMS AND ROCK TERMS

Usage with regard to time and rock terms is by no means uniform in the United States. There is general agreement upon the use of "era" for the major time divisions, but no term for the corresponding rock divisions has had wide acceptance. "Group" has been used in this sense, but it has had other uses, one of which is rather general, and therefore seems inappropriate. The divisions of an era are always called "periods," and the corresponding rock units are always called "systems." Some writers recognize "suberas" containing several periods, but this usage is not general. A period is divided into "epochs," and the corresponding rock units are "series," though both of these terms have been loosely used for smaller units. "Epoch," for example, is used by the United States Geological Survey for any division of time less than a period, though it is more common in everyday practice to use "time" in this sense—for example, "Oriskany time." Of the rock units less inclusive than series the most important is the "formation." Two or more formations may

be associated in a "group," ordinarily much thinner than a series, and within a formation subordinate named units called "members," "lentils," or "tongues" may be recognized. "Age," for a specific time unit, and "stage," for a rock unit, have been little used in America. "Horizon" has been used occasionally as if it were a material stratigraphic unit, but as in a strict sense a horizon has no thickness, meaning simply position, that usage is inappropriate.

The official classification of the United States Geological Survey recognizes, in descending order of importance, the following terms:

Time	Rock
Era	———
Period	System.
Epoch	Series.
Epoch	Group.
Epoch	Formation.
Epoch	Member, lentil, tongue.

DISCRIMINATION AND NAMING OF FORMATIONS

In American stratigraphy the formation is taken to be the fundamental unit of mapping. The concept of this unit is rather elastic, and no standard definition can be offered. It may be as simple an aggregate as a single uniform bed of rock or a succession of beds of like sediments. It may be with equal propriety an alternation of beds of unlike sediments, such as sandstone and shale, included between two breaks in the continuity of sedimentation or between two horizons where there is marked change in the aggregate lithology or some other evidence of important geologic events. Less commonly it consists of several beds grouped together because they contain throughout a related fauna, though not necessarily displaying lithologic unity. In brief, a formation may be any aggregation of beds that contains no important interruption and is bound together by some lithologic, stratigraphic, or faunal tie. In actual practice of field study or mapping, expedience or utility may be the deciding factor.

The thickness of a formation or the length of time it may represent is not an essential feature. A single sequence might conceivably contain a formation thousands of feet thick and another only a few feet thick. The first might contain members each many times thicker than the entire second formation; or the second might be divided into several members and the first be undivided. It is perhaps more often the case that the selection of boundaries is influenced by the necessities of cartographic

representation and that the units selected in a given area are more nearly comparable in thickness.

In naming formations it is the most general practice to adopt a geographic name derived from a "type locality" where the formation is present and sufficiently well exposed to constitute a standard of comparison. In practice it not infrequently happens that subsequent work reveals a better or more complete exposure than the type locality, and recourse is had to this as the actual standard rather than to the technical type locality. The geographic name originally selected, however, still stands as the valid name and is combined with either a lithologic term, if the formation is predominantly of one kind of rock, or the word "formation," if no single term is appropriate. This yields names like Dakota sandstone, Trenton limestone, Austin chalk, Genesee shale, Navarro formation, Dunkard formation, and Tejon formation. In general, priority in names is respected, and duplication of names is avoided, though no such rigidity of usage prevails as in biologic nomenclature; and it is sometimes expedient, where general use has established a later name, to waive consideration of priority and, where suitable names are scarce and the areas are widely separated, to accept a duplication.

Members, lentils, and tongues are smaller units essentially like formations and are discriminated and named in the same manner as formations. Indeed, it is not uncommon practice to consider a given set of beds in one area as a formation containing members and in another area as a group containing formations. It is entirely possible that in a third area this same set of beds might be considered a member of another formation of large scope. The same geographic name could be applied to the beds, whether they were viewed as a group, a formation, or a member. This elasticity of usage has its valuable aspects, but it is also a source of confusion.

A special type of name that should perhaps be noted here is that constituted by the naming of individual coal beds, fire-clay beds, oil sands, and comparable items. These names are confined usually to purely local units. They are applied by mine operators, drillers, economic geologists, or others connected with the mineral industry, and they are not often taken up in discussions of geologic nomenclature.

In extending the application of a name away from the type locality it is the general practice to apply it only to deposits similar in lithology to those of the type locality and supposedly continuous with the type locality, now or in the past. It is not the present practice to extend a name to extreme distances. Deposits that may be synchronous with those of the type local-

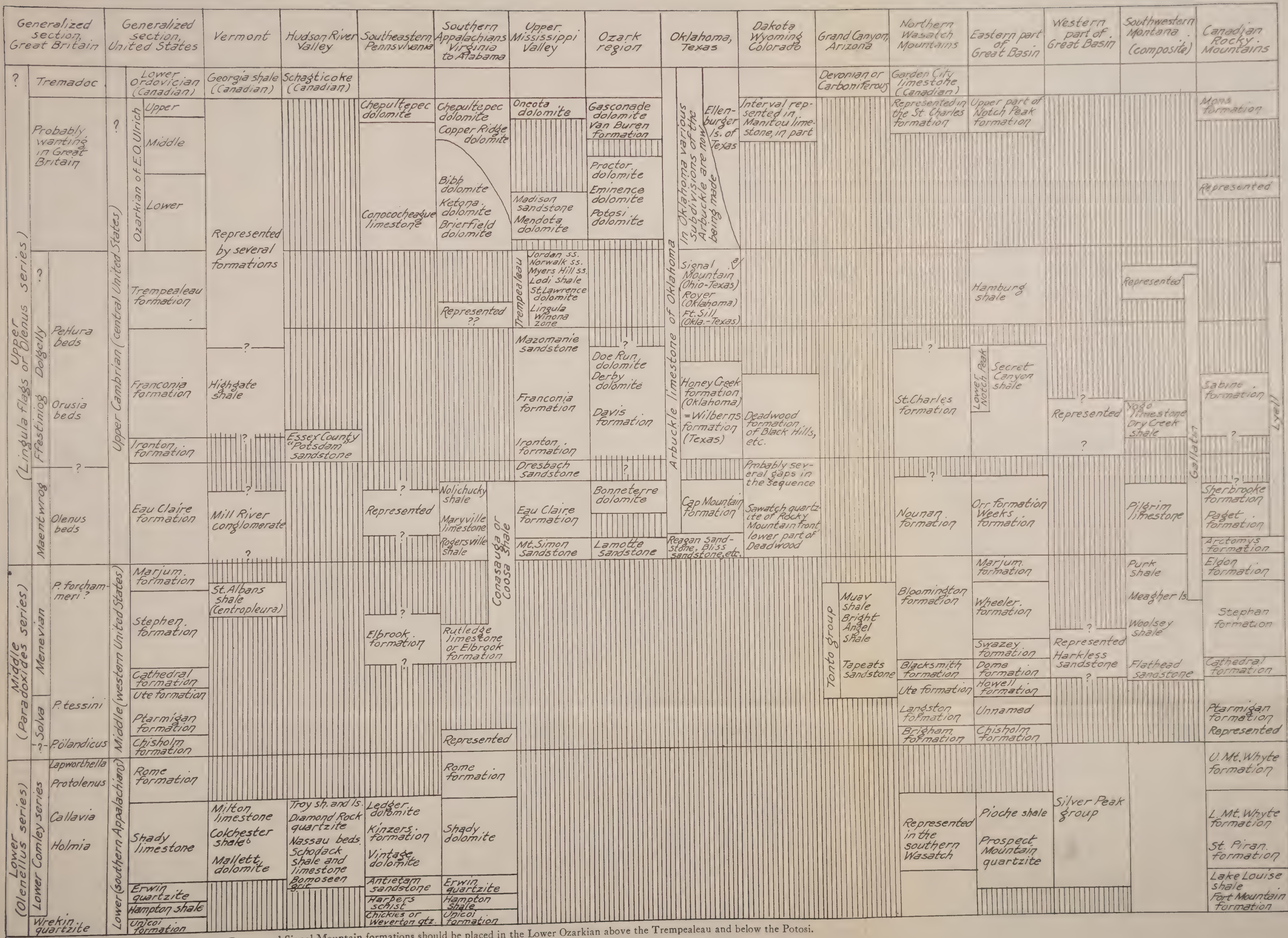
ity but are of different lithology are commonly given another name, and likewise those at a great distance. This is at variance with the common European practice of putting a geographic name into an adjectival form and extending it widely, without regard to lithology, to all deposits supposed to be synchronous with those to which the name was first applied—for example, Montian (calcaire de Mons). The adjective form is used also in America but only for the larger divisions and always with the implication that a time unit is intended.

CORRELATION TABLES

The appended series of tables (pls. 1–10) embodies a tentative correlation of representative local American systems of nomenclature for Paleozoic, Mesozoic, and Cenozoic rocks. On the left of each table is shown a European system of nomenclature, which, it is believed, will help those more familiar with it to date the units used in the United States. No attempt at completeness has been made, for complete tables would be too large to be practically useful, and indeed it is doubtful whether sufficient information is available to make even reasonably complete tables possible.

The conventions used are those commonly employed. Each vertical column represents a more or less local sequence—that recognized in the geographic unit indicated at the head of the column. Position within the columns represents relative age, the oldest unit at the bottom and the youngest unit at the top. Units alined horizontally are of the same age. Absence of rocks of a given age is represented by a ruled space in the part of the vertical column corresponding to the age. Vertical position does not imply relative thickness nor relative length of time. A query (?) placed on a line indicates doubt as to the vertical position of the line—that is, doubt as to the age of the feature for which it stands.

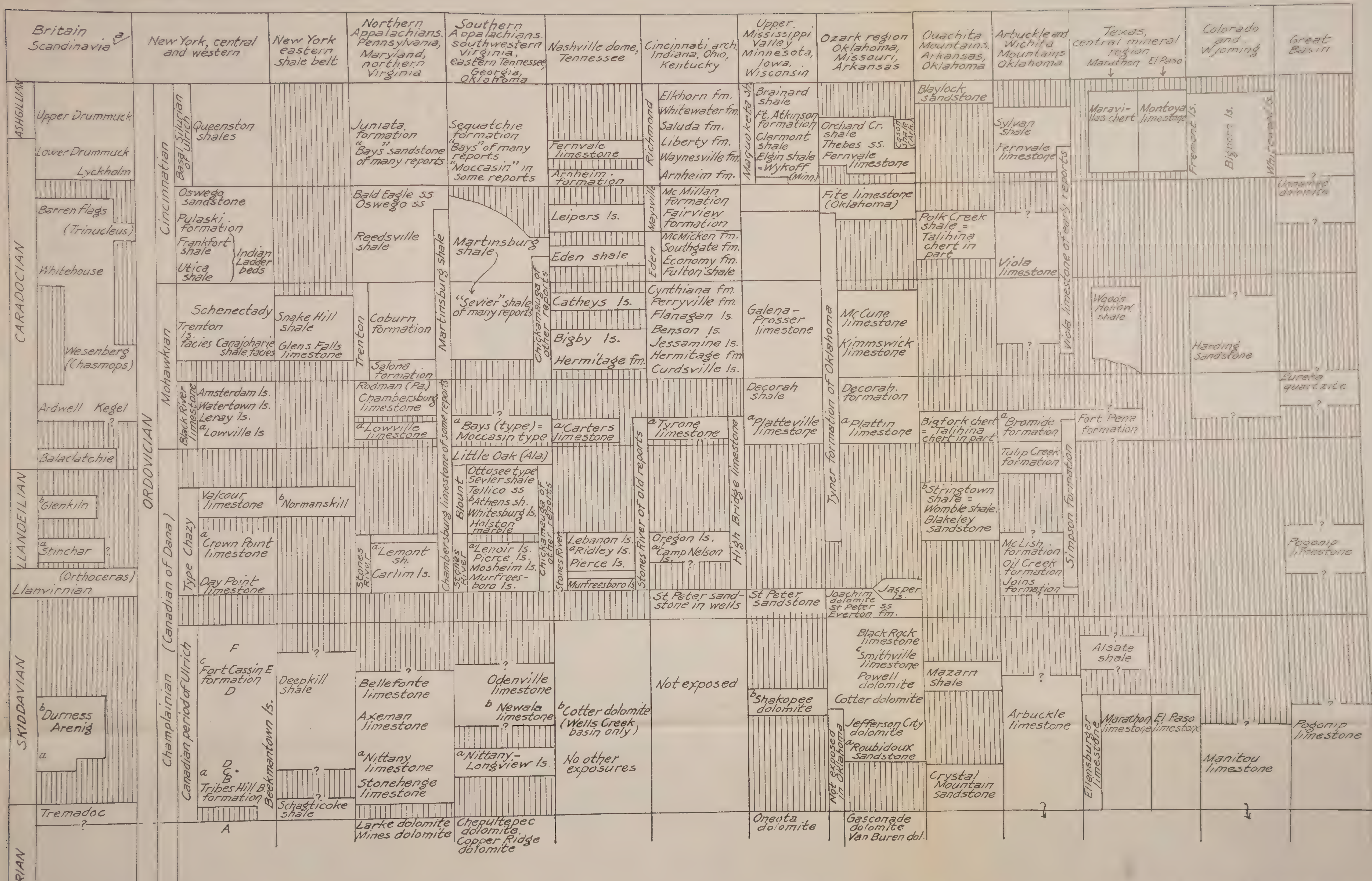
The correlations shown in the tables depart in some details from the official classification of the United States Geological Survey. These departures represent to some extent the opinions of the individual compilers and also to some extent the opinions of authors who are not members of the United States Geological Survey.



[a] According to E. O. Ulrich the Fort Sill, Royer, and Signal Mountain formations should be placed in the Lower Ozarkian above the Trempealeau and below the Potosi.
[b] The name Colchester shale has been replaced by Parker slate.

TENTATIVE CORRELATION OF THE CAMBRIAN FORMATIONS

Compiled by C. E. Resser and Josiah Bridge.



NOTE.—In the European column names at the right represent the Scandinavian section, and those in parentheses represent the Baltic region. Exact equivalents where known are indicated by small letters (a, b, c) preceding the names. In the Ozark region the relations of the Jasper and Joachim to each other are undetermined. Formations below the lower line are variously classified as Ordovician, Cambrian or Ordovician, Upper Cambrian, or Ozarkian. By inadvertence the heading "Texas central mineral region" was made to include the Marathon Basin and El Paso region. This heading should cover only the left-hand portion of the column. The Alsate shale and Fort Pena formation occur at Marathon but not in the central mineral region.

TENTATIVE CORRELATION OF THE ORDOVICIAN FORMATIONS

Compiled by Josiah Bridge.

	Europe	New York	Maryland and Pennsylvania	Eastern Tennessee	Ohio	Western Tennessee	Missouri	Eastern Wisconsin	Central-Southern Oklahoma	Utah - Idaho	Nevada	Texas - New Mexico
Overlying rocks		Lower Devonian	Lower Devonian	Lower Devonian	Middle Devonian	Lower Devonian	Lower Devonian	Middle Devonian	Lower Devonian	Middle Devonian	Middle Devonian	Upper Devonian or Carboniferous
UPPER SILURIAN	Downtonian(?): Downtonian Upper Ludlow	Cayugan: Manlius limestone Rondout waterlime Cobleskill limestone Salina formation	Tonoloway limestone Wills Creek shale (Bloomsburg sandstone) McKenzie formation	? Sneedville limestone ?	Monroan: Northern Ohio ?Detroit River series (Upper Monroe) Sylvania sandstone Bass Island series (Lower Monroe) Greenfield dolomite	? Decatur limestone ?		? Waubakee limestone ?				
MIDDLE SILURIAN	Salopian: Aymestry Lower Ludlow Wenlock	Niagaran: ? Lockport dolomite (including Guelph dolomite) ? ? Clinton beds Rochester shale ? Irondequoit limestone, etc.	? Rochester formation Rose Hill formation	?Louisville limestone	Central Ohio to Louisville, Ky Louisville limestone ? Waldron shale Laurel limestone ? ? Osgood limestone ?	Lobelville limestone Bob Beech Riv. ls. ls. Dixon limestone Lego limestone ? Waldron shale Laurel limestone ? ? Osgood limestone ?	? Bainbridge limestone ?	? Guelph dolomite ? ? Racine dolomite (Hopkinton dol. of Iowa) Waukesha dol. Mayville dolomite ?	? Henryhouse shale ? Middle Hunton (pars) ? ? St Clair limestone (N.E. Oklahoma) ?	? Laketown dolomite ?	? Lone Mountain dolomite ?	? Fusselman dolomite ?
LOWER SILURIAN	Valentian or Llandovery: Upper Middle Lower	Medinan (Albion): Upper Medina sandstone Albion sandstone	? Tuscarora sandstone (Medina) ?	Rockwood formation / Clinch sandstone: Brassfield limestone White Oak sandstone ?	Brassfield limestone	Brassfield limestone	Brassfield limestone (Sexton Creek) ? Alexandrian: Edgewood limestone (Noix oolite) Girardeau limestone ?	Iron Ridge iron ore	Chimney Hill limestone (Lower Hunton) ?			
Underlying rocks	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician	Upper Ordovician

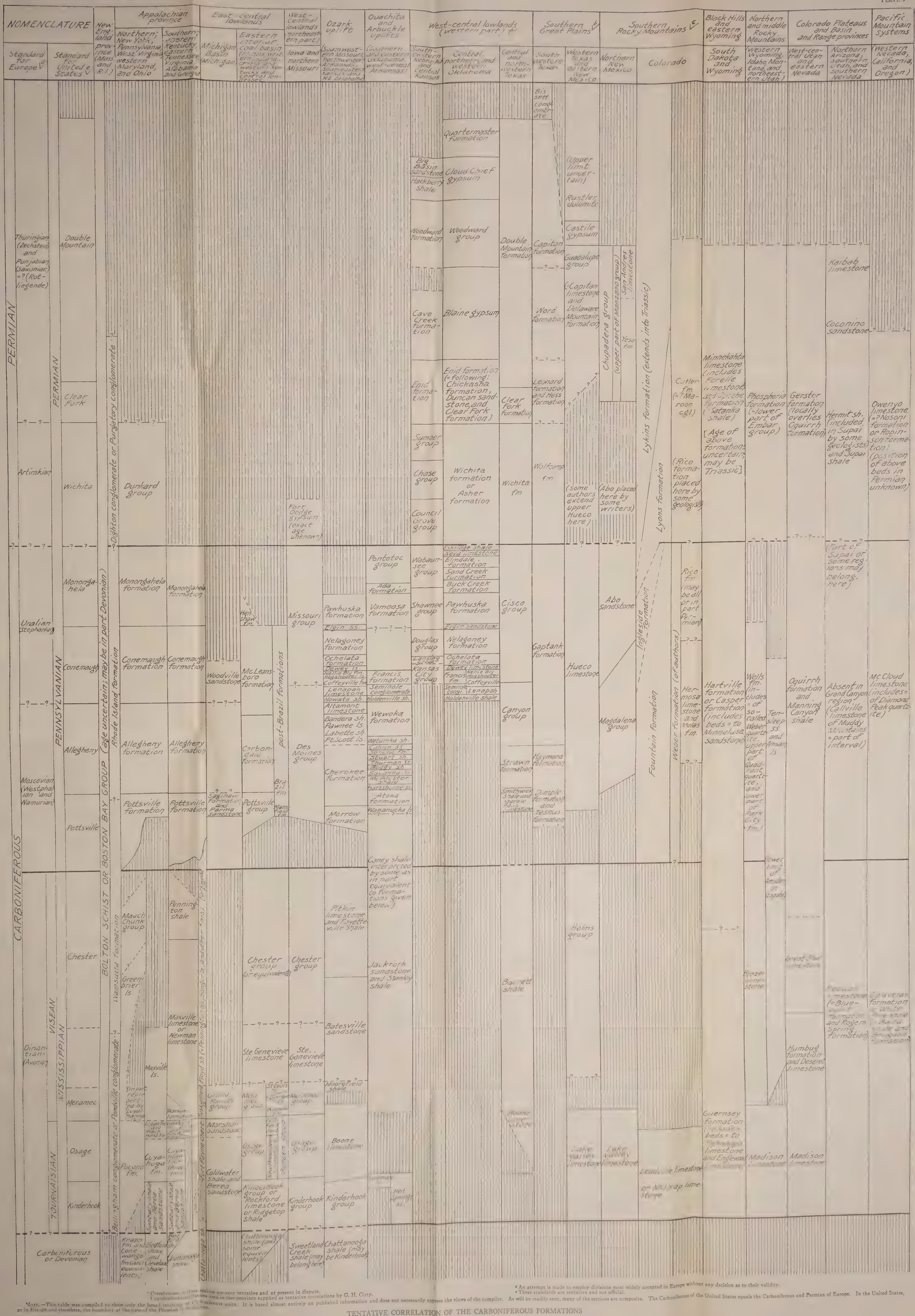
TENTATIVE CORRELATION OF THE SILURIAN FORMATIONS

Compiled by Edwin Kirk.

	Europe	New York	Maryland and Pennsylvania	Southern Ohio and Indiana	Western Tennessee	Missouri	Iowa	Michigan	Colorado	Montana, Utah, Idaho	Central Nevada	Arizona
Over-lying		Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous	Lower Carboniferous
Upper Devonian	Famennian Frasnian	Chautauquan: Chemung formation Senecan: Portage form., Genesee shale, Tully limestone	Jennings formation	New Albany shale	Hardin sandstone	Central Missouri Snyder Creek shale	Lime Creek shale (Hackberry shale) State Quarry limestone	Antrim shale	Chaffee formation (Central Colorado) Elbert ss., Ouray ls. (Southern Colorado)	Three Forks shale	Nevada limestone	Martin limestone
Middle Devonian	Givetian Eifelian (Couvinian)	Erian: Hamilton formation, Marcellus shale Ulsterian: Onondaga limestone, Schoharie grit	Romney shale	Sellersburg limestone Jeffersonville limestone	Pegram limestone Camden chert	Callaway limestone Mineola limestone Southeastern Missouri St. Laurent limestone Grand Tower limestone	Cedar Valley limestone Wapsipinicon limestone	Traverse group Dundee limestone		Jefferson limestone	Nevada limestone	
Lower Devonian	Emsian (Coblentzian) Siegenian (Gedinnian)	Oriskanian: Esopus grit, Oriskany sandstone Helderbergian: Becraft limestone, New Scotland limestone, Coeymans limestone, "Upper Manlius" (Keyser)	Oriskany sandstone Becraft limestone New Scotland limestone Coeymans limestone Keyser limestone		Harriman chert Linden formation: Decaturville chert, Birdsong shale, Olive Hill ls. Rockhouse shale	Little Saline limestone Bailey limestone						
Under-lying		Upper Silurian	Upper Silurian	Middle Silurian	Upper Silurian	Middle Silurian	Upper Silurian	Upper Silurian	Upper Ordovician to pre-Cambrian	Middle Silurian to Cambrian	Middle Silurian	Upper Cambrian

TENTATIVE CORRELATION OF THE DEVONIAN FORMATIONS

Compiled by Edwin Kirk.



[a] Correlations in these regions are very tentative and at present in dispute.

[b] Unpublished correlations used in this province supplied as tentative correlations by G. H. Girty.

[d] An attempt is made to employ divisions most widely accepted in Europe without any decision as to their validity.

[e] These standards are tentative and not official.

NOTE.—This table was compiled to show only the broad relations of Carboniferous units. It is based almost entirely on published information and does not necessarily express the views of the compiler. As will be readily seen, many of the sections are composite. The Carboniferous of the United States equals the Carboniferous and Permian of Europe. In the United States, as in Europe and elsewhere, the boundary at the base of the Permian is in dispute.

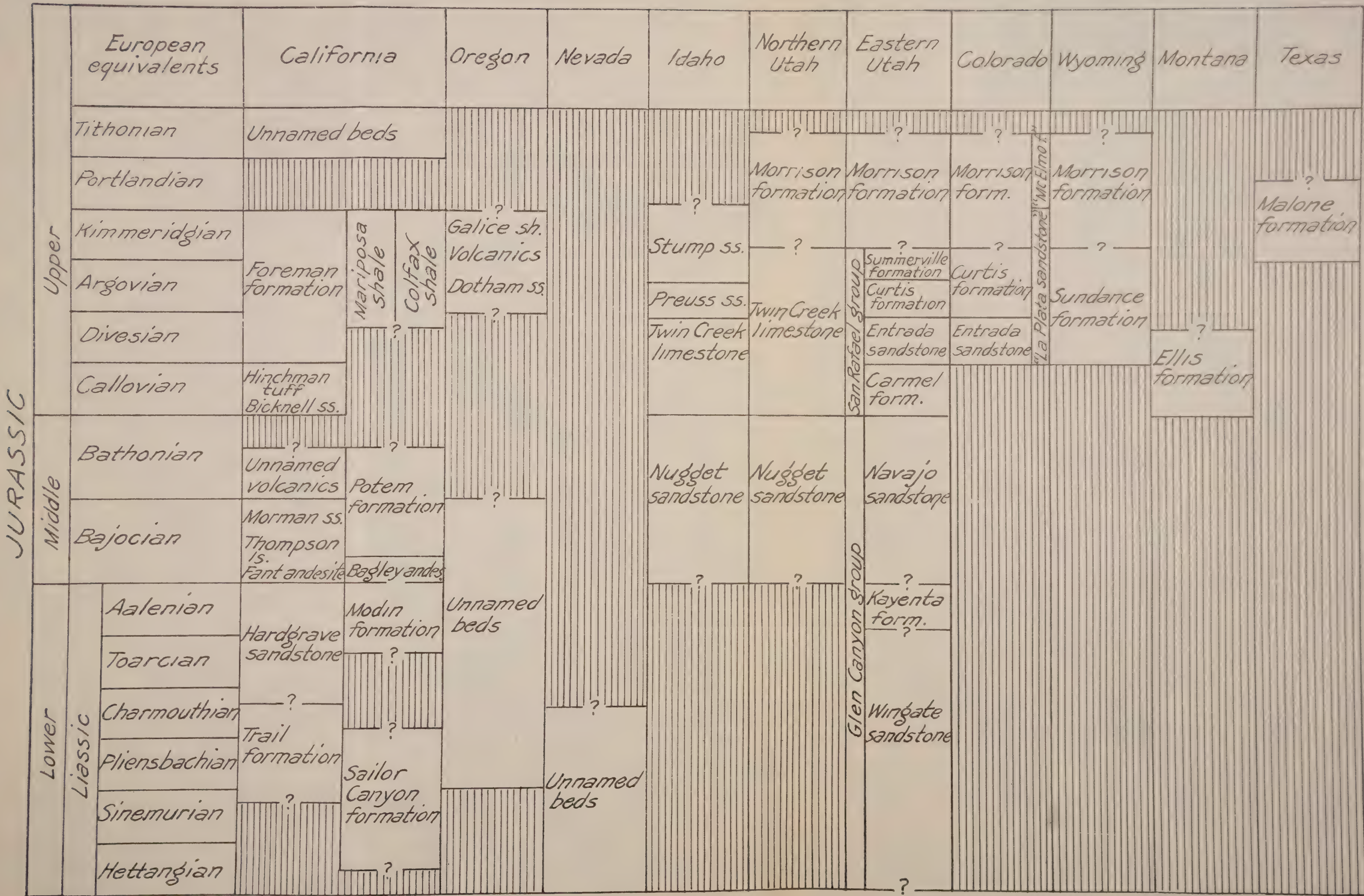
TENTATIVE CORRELATION OF THE CARBONIFEROUS FORMATIONS

Compiled by J. S. Williams.

European equivalents				California		Nevada	Idaho	Northern Utah		Arizona and southern Utah	Colorado	Wyoming	Texas	Atlantic States
TRIASSIC	Upper	Bajuvaric	Keuper Rhaetic	?		?	? Wood shale	?		?	?		?	?
			Noric	Brock shale; Hosselkus limestone	Pseudomonotis zone; Coral zone	Star Peak formation	Deadman limestone; Higham grit	Ankareh formation		Chinle formation	Dolores formation		Dockum group	Newark group
		Tirolic	Karnic	Hosselkus limestone	Tropites zone; Halobia zone	Star Peak formation	Timothy sandstone; ?	Ankareh formation; ?		Shinarump cong.; ?	?	? Popo Agie and Jelm formations	?	?
	Middle		Ladinic	Pit shale	Daonella zone	Star Peak formation						Popo Agie and Jelm formations		
		Dinaric	Muschelkalk Anisic	Pit shale	Daonella zone	Star Peak formation	?	?				?		
			Hydaspic				Portneuf formation; ?	Thaynes formation	Emigration form.; ?	?		?		
	Lower	Scythic	Bunter Jukutic	Unnamed beds	Meekoceras zone	Unnamed beds	Fort Hall fm.; ?; Ross Fork fm.	Thaynes formation	Pinecrest formation; ?	Moenkopi formation		Chugwater formation		
			Brahmanic				Woodside formation; ?	Woodside formation; ?		Moenkopi formation; ?		Dinwoody formation		

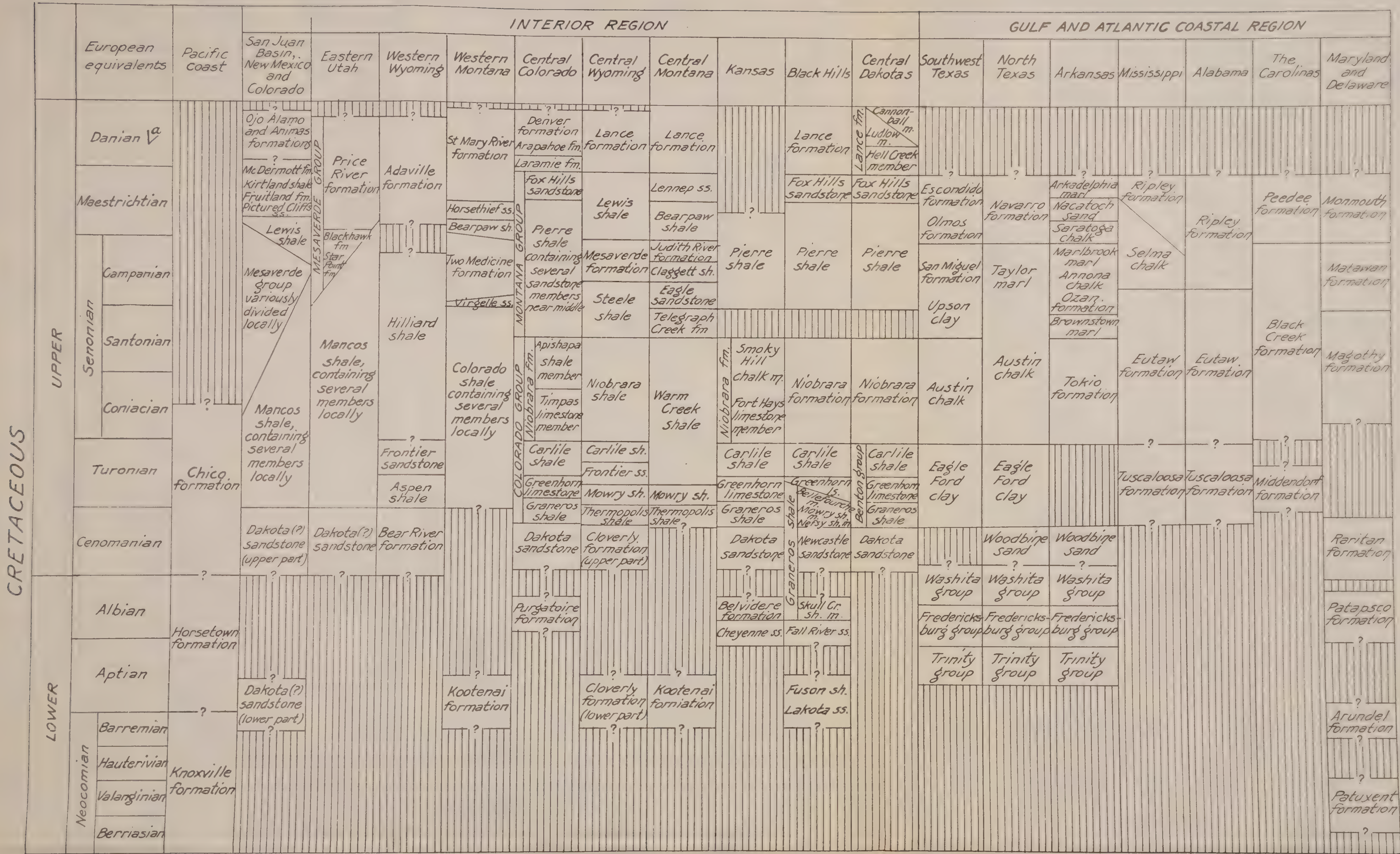
TENTATIVE CORRELATION OF THE TRIASSIC FORMATIONS

Compiled by John B. Reeside, jr.



TENTATIVE CORRELATION OF THE JURASSIC FORMATIONS

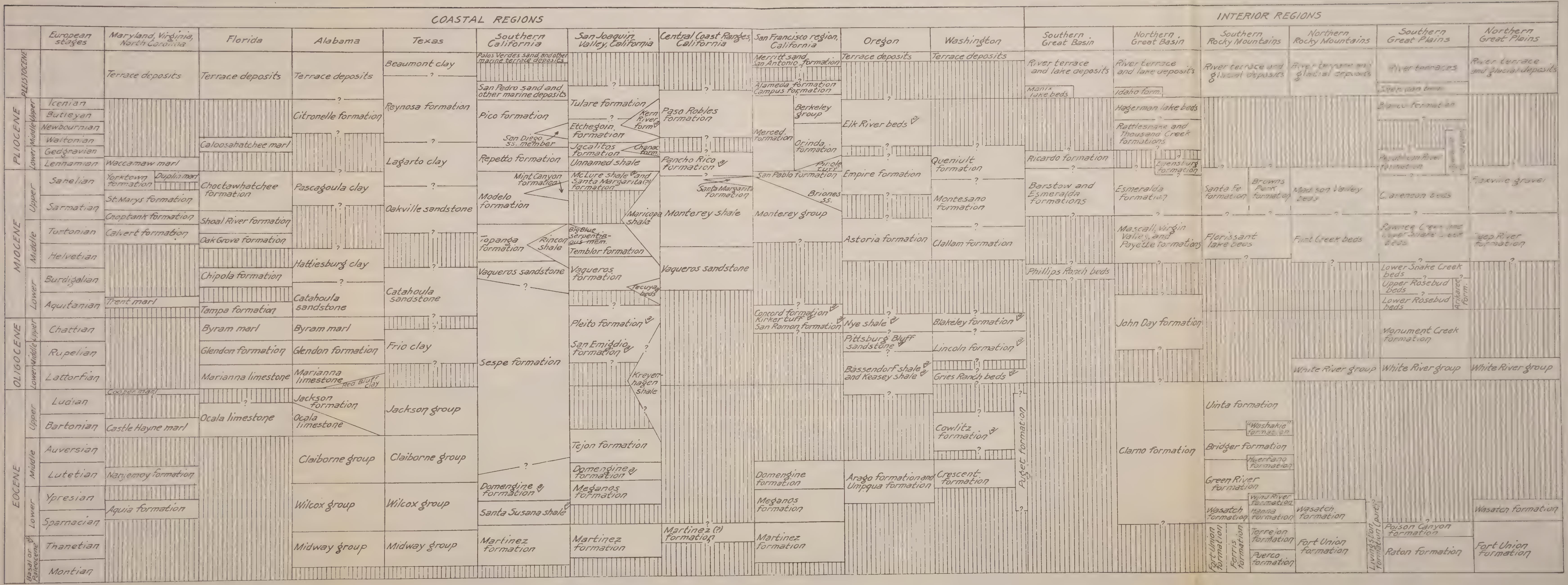
Compiled by John B. Reeside, jr.



[a] The correlation of formations here shown as of Danian age is much disputed. In the legend of the geologic map of the United States and in the official classification of the United States Geological Survey the Ojo Alamo, Animas, and Lance formations are placed in the Eocene (?) and the Arapahoe and Denver formations are placed in the Eocene.

TENTATIVE CORRELATION OF THE CRETACEOUS FORMATIONS

Compiled by John B. Reeside, jr.



ᵃ Names that have not been adopted by the United States Geological Survey.

TENTATIVE CORRELATION OF THE TERTIARY AND PLEISTOCENE FORMATIONS

Compiled by W. P. Woodring and C. L. Gazin.

Period / epoch	European Alps (Penck and Brückner)	Yosemite Valley, California (Matthes)	Sierra Nevada (east flank) (Blackwelder)	San Juan Mountains, Colorado (Atwood, Mather)	Puget Sound region, Washington (Willis, Smith, Bretz)	Eastern Washington (Bretz)
RECENT EPOCH	Recent epoch	Mountain glaciers and streams	Mountain glaciers and streams	Mountain glaciers and streams	Mountain glaciers and streams	Streams
PLEISTOCENE EPOCH	Würm glacial epoch	Wisconsin glacial stage	Tahoe glacial stage	Wisconsin glacial stage	VASHON EPOCH: Vashon glacial drift (Puget Sound) Osceola glacial drift (of Cascade glaciers)	Wisconsin glacial stage (lakes and streams)
	Würm-Riss interglacial	Cycle of erosion	Cycle of erosion	Cycle of erosion	PUYALLUP INTERGLACIAL EPOCH: Douty gravel mountain glaciers ?	Palouse loess Cycle of erosion
	Riss glacial epoch	?	Tioga glacial stage	Durango glacial stage	Puyallup sand and lignite ?	Spokane glacial stage
	Riss-Mindel interglacial epoch	Cycle of erosion	Cycle of canyon erosion	Cycle of canyon erosion	Orting gravel ?	?
	Mindel glacial epoch	El Portal glacial stage	Sherwin glacial stage	FLORIDA CYCLE: Florida group (partly outwash) Cerro glacial stage	ADMIRALTY EPOCH: Admiralty glacial till	Glacial stage? (Till at Cheney)
	Mindel-Günz interglacial epoch	Cycle of canyon erosion	Cycle of erosion	Cycle of broad valley erosion	?	?
	Günz glacial epoch	Glacier Point glacier stage	McGee glacial stage	? ?		
OLIGOCENE, MIOCENE, AND PLIOCENE		Cycle of erosion Uplift Cycle of erosion of broad valleys	? Pliocene ? Miocene	? (Uplift) San Juan peneplain (cycle of erosion)		

European Alps (Penck and Brückner)	Northern Idaho, western Montana (Alden, Pardee, Anderson)	Wind River Mountains, northwestern Wyoming, southeastern Idaho (Blackwelder)	Eastern Montana, northwestern North Dakota, western Wyoming (Alden)	Period / epoch	Upper Mississippi Basin and Great Lakes region U.S. Geological Survey (Chamberlin, Leverett, et al)	Western Minnesota, eastern Dakotas, northwestern Iowa (Leverett	Eastern Minnesota, northeastern Iowa (Leverett)
Recent epoch	Mountain glaciers and streams	Mountain glaciers and streams	Mountain glaciers and streams		Lakes and streams	Lakes and streams	Lakes and streams
Würm glacial epoch	Wisconsin glacial stage and glacial Lakes Kootenai and Missoula.	Pinedale glacial stage	Wisconsin glacial stage. Late and middle or early (?) of Keewatin ice sheet and mountain glaciers	QUATERNARY PERIOD PLEISTOCENE EPOCH	Wisconsin glacial stage. Late, middle, early. glacial lakes	Wisconsin stage of Keewatin ice. late (Lake Agassiz per Upham) ?	Wisconsin glacial stage. Late Keewatin and Patrician. Middle Patrician ice ?
Würm-Riss interglacial	Cycle of erosion	(Loess in southeastern Idaho) Lenore cycle of erosion	Sangamon or Peorian interglacial soil and erosion		Peorian interglacial Iowan glacial stage Sangamon interglacial stage	Peorian interglacial Iowan stage of Keewatin ice sheet Sangamon interglacial stage	Peorian (Loess) Iowan stage of Keewatin ice sheet ?
Riss glacial epoch	Glacial stage (Mission moraine and glacial Lake Missoula) (Till at Elliston on "No.2" terrace	Bull Lake glacial stage	Illinoian or Iowan stage of Keewatin ice sheet and Rocky Mountain glaciers?		Illinoian glacial stage	?	Illinoian stage of Patrician ice sheet
Riss-Mindel interglacial epoch	Cycle of erosion (Canyons in mountains) Uplift	Circle cycle of erosion	Cycle of erosion "No.2" terraces Uplift		Yarmouth interglacial stage	Yarmouth interglacial stage	Yarmouth interglacial stage
Mindel glacial epoch	Glacial stage (till at Jocko and Helmville)	Buffalo glacial stage	Glacial stage (Till of Rocky Mountain glaciers on high "No.1" piedmont terrace, Glacier National Park, near Helena, Castle Mountains. High till on Beartooth Mountains ? ? ?		Kansan glacial stage	Kansan glacial stage	Kansan glacial stage
Mindel-Günz interglacial epoch	Cycle of erosion Uplift	Black Rock cycle of erosion ?			Aftonian interglacial stage	Aftonian interglacial stage	Aftonian interglacial stage
Günz glacial epoch	Glacial stage (till at Pioneer and upper Madison River)	? ?	Glacial ? boulder bed on Table Mountain at Wind River and on Moncrief Ridge at Big Horn Mountains		Nebraskan glacial stage	Nebraskan glacial stage	Nebraskan glacial stage
	Erosion and "No.1" terraces Uplift and faulting Bozeman "lake beds" (intra-montane)	Union Pass cycle of erosion Fremont cycle of erosion (Sub summit peneplain)	Flaxville cycle of erosion. Broad mountain valleys and "No.1" terraces Uplift Sub summit Beartooth peneplain and Cypress Plain. (Miocene-Oligocene)				

European Alps (Penck and Brückner)	Iowa Recently proposed for upper Mississippi Basin and Great Lakes region (Kay)	Illinois (Leighton)	Michigan, Indiana, Ohio, western Pennsylvania (Leverett)	Eastern Pennsylvania, New Jersey (Salisbury, Leverett in part)	Long Island, New York (Fuller)	New England Islands, Cape Cod (Woodworth, Wigglesworth)
Recent epoch	Recent stage	Recent epoch	Lakes and streams			
Würm glacial epoch	PLEISTOCENE PERIOD ELDORAN EPOCH: Wisconsin glacial stage Mankato ? (loess) Iowan	PLEISTOCENE EPOCH Wisconsin glacial stage Mankato Cary (loess) Tazewell (loess)	Wisconsin glacial stage Late Middle Early	Wisconsin glacial stage	WISCONSIN: Glacial stage Late ? Harbor Hill substage Ronkonkoma substage	WISCONSIN: Glacial stage, Late ? Falmouth substage Nantucket substage
Würm-Riss interglacial	CENTRALIAN EPOCH: (loess) Sangamon Interglacial stage	(loess) Sangamon interglacial stage	Peorian interglacial (loess) Sangamon interglacial stage	Sangamon interglacial stage	VINEYARD: Interglacial stage (erosion) (uplift)	VINEYARD: Interglacial stage erosion and Vineyard formation (partly marine)
Riss glacial epoch	(loess) Illinoian stage of Labrador ice sheet	Illinoian glacial stage	Illinoian glacial stage	Illinoian glacial stage (per Leverett)	MANHASSET: Glacial stage Hempstead (gravel) Montauk (till) Herod (gravel)	MANHASSET: Glacial stage Hempstead (gravel) Montauk (till) Herod (gravel)
Riss-Mindel interglacial epoch	OTTUMWAN EPOCH: (loess) Yarmouth interglacial stage	Yarmouth interglacial stage	Yarmouth interglacial stage	Interglacial stage (erosion)	JACOB: Transitional (sand) Interglacial GARDINERS: Gardiners (clay) (Marine submergence)	JACOB: Jacob (sand) Interglacial GARDINERS: Gardiners (clay) (Marine submergence)
Mindel glacial epoch	Kansan glacial stage	Kansan glacial stage	Glacial pebbles and boulders (extra-morainal)	Jerseyan glacial stage and Pensauken marine ?? partial submergence	JAMECO: Glacial stage Jameco (glacial? gravel)	JAMECO: Glacial stage Moshup till Coarse gravel Ferruginous boulder bed
Mindel-Günz interglacial epoch	GRANDIAN EPOCH: Aftonian interglacial stage	Aftonian interglacial stage	?	?	POST-MANNETTO: Interglacial stage. (erosion)	POST-MANNETTO: Interglacial stage. (erosion)
Günz glacial epoch	Nebraskan glacial stage	Nebraskan glacial stage	?	?	MANNETTO: Glacial stage Mannetto (glacial? gravel)	MANNETTO: Glacial stage Mannetto formation, glacial gravel and till, folding due to ice push. Weyquosque glacial sqr. Sankaty marine sand. Dukes glacial boulder bed
						PLEISTOCENE: Aquinnah conglomerate (Stream gravel with fossils) MIOCENE

TENTATIVE CORRELATION OF QUATERNARY GLACIAL AND ASSOCIATED PHENOMENA

Compiled by William C. Alden.